ORIGINAL ARTICLE

OPEN ACCESS

Drivers of Strategic Alliances: The Influence of Technological Diversification and Operational Efficiency

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Submitted: June 03, 2020
Revised: September 19, 2020
Accepted: October 28, 2020
Published online: December 30, 2020

ABSTRACT

For many decades, pharmaceutical firms have been forming strategic alliances to increase their R&D productivity and expand their geographical footprint. Recently, the alliances are driven by the increase of technological diversity and efficiency of firms. This paper analyses empirically the influence of internal factors on strategic partnership. We test our hypotheses using a longitudinal study of 186 strategic alliances in the bio- pharmaceutical industry in three major industrialized regions (U.S, Europe, and Asia) during the period from 2003 to 2013. The research findings reported that the last operational efficiency has a positive effect on the number of strategic alliances in the bio-pharmaceutical industry. However, technological diversity emerged as a negative driver of bio-pharmaceutical firms engaging in strategic alliances.

Keywords: Strategic alliances; Technological diversification; operational efficiency; bio- pharmaceutical.

1 | INTRODUCTION

At the commencement of an innovative decade, it is appropriate to reveal that where the industry is going and from where it has appeared. The appearance of biotechnology in the late 1970s direct to the appearance of the alleged new biotechnology firms (NBFs). These firms, which have innovative products and ideas but often require the financial resources from the financial perception, and from the management perception they often need management expertise. To fulfill these requirements, they are ideal aspirants for joint arrangements with incumbent pharmaceutical firms. The biopharmaceutical firms made immense progress in the previous 4 decades largely working alone. Though, the industry has developed to the point where there is a greater need to collaborate and recognition that future problems are more probable to be solved by working jointly. The National Institute for innovation in Manufacturing Biopharmaceuticals (NIIMBL) is directing this cultural change in the USA by mounting a mutual vision of the future and structuring a partnership of people from government, industry and academia to do things we might never do by our own. Its mission is to hasten biopharmaceutical manufacturing modernization, sustain the improvement of standards that facilitate more proficient and fast manufacturing potentials, and train and educate a world-leading biopharmaceutical modern workforce, primarily proceeding US competitiveness in this industry.

The Last two decades have seen an extraordinary increase in strategic alliances between variousfirms (Dyer et al., 2001), particularly in intensive industries, which are becoming increasinglymore effective in bio-pharmaceutical companies and more relevant for businesses of all sizes (Ohba & Figueiredo, 2007; Dan & Zondag, 2016). Technological evolution, financial constraints, knowledge deficiencies and market inefficiencies are some of the most frequently stated reasons for firms to enter into jointly ventures with other firms. The main objective of Strategic alliances is to overcome these challenges and gain competitive advantage through accessing new technologies and markets, undertaking joint product development, obtaining situational knowledge and, in general, achieving a market position that would be unattainable for the alliance partners in isolation (He et al. 2020; Foroohar, 2018). Strategic alliances (SA) are partnerships of two or more business units or corporations that work jointly to attain strategically major objectives that are commonly beneficial. The potential of SA is enormous, if implemented correctly. It can significantly advance the organization's functions and competitiveness (Elmuti and Kathawala, 2001). The concept of strategic alliances especially in this industry can be traced back to the period of 1960s (Bellussi & Osri, 2015). According to Gulati (1998), strategic alliance is defined as "[…] voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services.

Various authors point out a multitude of reasons to explain firms' motivations to seek strategic alliances (Hegedoorn, 1993). These motivations include enhancing a firm's efficiency (Ahuja, 2000), entering new markets (Garcia-Canal et al., 2002), being able to quickly diffuse new technologies (Kale et al., 2000), filling out product lines and portfolios, reducing the costs, risks, and time required to develop new products and process technologies (Elmuti & Kathawala, 2001). Therefore, the reason to seek an alliance between two or more parties is commonly the result of a set of firm's internal motives. Particularly, horizontal strategic alliance refers to an alliance process among different firms that are active in the same business area (Perry et al., 2004; Haeussler et al., 2012).

The two distinct categories of strategic alliances that companies in the biopharmaceutical industry have typically engaged are: (1) Partnerships; that are mostly oriented towards conducting joint research or exchanging technological knowledge (technology-transfer agreements, R&D alliances, licensing agreements, and joint ventures), and (2) Alliances; that are predominantly focused on joint-commercialization activities (manufacturing and marketing agreements) (Rybka et al. 2015).

Rising technological intricacy, rapid product life-cycle and high cost of product novelty obliges many pharmaceutical companies and biotech to unite forces in the advance of new treatment and drugs, and consequently sales and marketing (Oxley and Sampson, 2004). These alliances are advantageous to the biotech since they serve as a significant source of investment, and augment the odds of their consent by regulatory authorities. At the same time, they are also important to the pharmaceutical companies, since they maintain their product lines large and up to date.

Bio-pharmaceutical strategic alliances are characterized by the diverse characters played by the strategic partners. Biotech's are in general minor and thus extra agile innovator companies that license technologies and products to pharmaceutical companies that will convey products to the market (Rothaermel and Boeker, 2008). Hence, the technical aptitude of the biotech are paramount for a winning alliance, the capability of the pharmaceutical firm to effectively run the different therapeutic classes, i.e. market segments it runs in, is evenly significant to alliance achievement.

The strategic alliance between bio-pharmaceutical industry and the high-technology sector, which is accepted as one of the most promising industries in the current century (Ramasamy et al., 2015; Lalor et al., 2019). As a result of its high investment, long R&D cycles, and advanced technology requirements, the biopharmaceutical industry is characterized by high -risk, high - levels of knowledge (Schuhmacher et al., 2013), and high costs (Chang et al., 2019). It looks at pharmaceutical and biotechnology companies of different sizes and from various geographical regions. This industry sample has been chosen because the development of new drugs or the improvements of existing products are the main activity in the extremely innovative pharmaceutical sector (Rothaermel, 2001). Also, there are a larger number of strategic alliances among these firms, in contrast to other high technology sectors (Hagedoorn, 1993; Rothaermel& Deeds, 2006; Marhold et al., 2017) who enable the transfer of technology, enhance competitiveness, increasing product diversity and best practices (Koka & Prescott, 2008; Changet al., 2019).

The intensity of technological diversification has attracted the attention of researchers (Garcia-Vega, 2006; Quintana-Garcia et al., 2008; Corradini et al., 2016; Natalicchio et al., 2017; Bali et al., 2019). It is consistently identified as a crucial management decision of companies in their innovation activities. They are always looking to expand their technological capabilities to wider technological fields rather than being limited to one technology. These act in a complementary fashion to the firm's core business (Cohen, 1995; Gambardella & Torrisi, 1998; Leten et al., 2007; Quintana-Garcia et al., 2008; Chen et al., 2010; Kim et al., 2016; Pan et al., 2018). In the same vein, according to previous studies, technological diversification is an indicator of firm performance (Granstrand, 2000; Quintana-Garcia et al., 2008; Huang & Chen,2010; Lai & Weng, 2013; Kook et al., 2017), and technological performance (Leten et al., 2007; Bolli et al., 2013, 2019) through significant economies complementing each other (Fai & Cantwell, 1999; Piscitello, 2004; Lavie & Miller, 2008). Therefore, firms have to be able to handle a large number of technologies in order to develop and produce products and services. Despite the wide body of literature provides many insights into the drivers of alliances, it remains lacks investigations in some areas.

In fact, there is a broad body of literature that investigated various measures related to the impact of the alliance's portfolio on the technological diversity of firms (Leten et al., 2007; Quintana-Garcià et al., 2008; Van de Vrande, 2013; Franco & Haase, 2015) that focused on patterns of technological diversification that limit the firm's ability to ally with others when taking into account its interaction (Hohberger et al., 2015; Zhou & Wan, 2017).

Overall, to the best of our knowledge, no prior empirical research within strategic literature has focused on the inverse impact of operational efficiency driving partnership alliances in the bio-pharmaceutical industry. Therefore, it deserves further attention. To achieve these objectives, we constructed a sample of 72 bio-pharmaceutical companies of different sizes in three major industrialized regions (U.S, Europe, and Asia) which engaged in 186 non-equity strategic alliances from 2003 to 2013. We constructed a model of the longitudinal data, collected from several sources, such as Recap IQ, MedTrack, Osiris, Bloomberg's, and Qpat/Orbit databases.The number of alliances the firm entered into with one or more allies is used as the dependent variable.

The paper is organized as follows. The following section outlines the theoretical framework with the hypotheses, and insights into the drivers of strategic alliances. The third section of thispaper describes the research methodology, data, and the variables used in the analysis. The fourth section will present the results. Finally, we conclude with a discussion.

2 | THEORETICAL FRAMEWORK AND HYPOTHESES

Over the last few decades, more and more companies and industries understand that they cannotsurvive alone due to the increase in global competition and the fast rate of technological change.The increases in the complexity of products and product processes over time have also caused them to recognize the pressing need for alliances (Rosenberg, 1976; Mohr & Spekman, 1994; Granstrand et al., 1997; Doz & Hamel, 1998; Ireland et al., 2002; Breshi et al., 2003; Lo et al.,2016). This is in turn proven by the evolution of the number of strategic alliances, particularly in technology-intensive industries (Hagedoorn, 1993). Therefore, firms might expand their technological base by acquiring external sources of knowledge and maintain their competitive advantage and innovation across industries and countries (Granstrand 2003; Dahlander & Gann, 2010; Belderbos et al., 2014; Zhang & Tang, 2018).

Especially, in bio-pharmaceutical industries firms tend to be highly diversified in an environment characterized by a fast-changing technology, which mainly depends on thegeneration of new ideas or development of the existing products. For successful innovation, not just the amount of resources held by a firm, but also their diversity is important. More various internal resources improve the firms' aptitude to innovate through resource recombination (Galunic & Rodan, 1998).

Previous studies have conceptualized technological diversity as a surging tendency in industrialized states (Leten et al., 2007, Lalor et al., 2019). Other studies found that technological diversity has avery similar profile among the largest firms producing similar products (Patel & Pavitt, 1995; Giuri et al., 2002; Ceipek et al., 2019) and is a good predictor for future product diversification and performance

(Pavitt, 1998). Moreover, firms have patents concentrated in the same technological classes in line with their goal in strategic alliances (Giuri et al., 2004; Li, 2019; Comai, 2019; Jee & Sohn, 2020).

With regards to our study interest, the influence of technological diversity and its increase overtime on strategic alliances in biopharmaceutical firms, except the paper of Giuri et al., (2004) that analyzes the role of diversification on the tendency to engage in such agreements across various dimensions. This subject has not been sufficiently treated in the literature. In their study comparing firms' internal technological profile with their propensity to engage in external alliances, they find that there is a strong correlation between firms that are well-diversified technologically and their relationships or alliances. Furthermore, the authors, with regards to industry particulars, suggest that there are cross-sectoral differences in diversification level. The chemical and pharmaceutical industry firms tend to have patents concentrated in the sametechnological fields as the sample average in which they take part in alliances.

The existing studies on technological diversification view it as a way for firms to reduce the transaction costs of purchasing technologies from the market and strategy to differentiate themselves (Leten et al., 2007; Bolli et al., 2013, 2019). Such studies believe that this method enables specialized firms to perform better than their competitors and is hard to imitate them because of their distinct and rarity (Lavie & Miller, 2008). Overall, the use of various strategies to obtain the internal resources of the firms is an asset in gaining access to the external sources of knowledge and resources. Basically, firms with lack diverse internal resources try to form relationships gaining them access to the complementary competencies and diverse external knowledge and technologies of other firms for innovation (Arora et al., 2001; Schildt et al., 2005; Comai, 2019). In contrast to this, firms with large technology portfolios tend to rely heavily on external sources of knowledge throughacquisition, outsourcing, or collaboration, giving them the ability to exploit successfully this relevant technological expertise that is beyond the firm's core business (Lichtenthaler & Ernst, 2007; Cassiman & Veugelers, 2006).

Empirically, some researchers have focused on particular alliances used in various industries totest the relationship between strategic alliances and firm performance. For example, Sapmson (2007) in his sample of 463 R&D alliances in the telecommunication equipment industry findsthat technological diversity has a moderate impact on firm innovation, contrary to alliances thatcontribute far more to firm innovation. Very consistent with this empirical finding, Koren & Tenreyro (2013) used the 1997 capital flow tables of the bureau of economic analysis for 180 good capital categories. Their study shows that technological diversification is significantly and positively correlated with the level of labor productivity and negatively, but significantly, associated with sectoral volatility. According to Mindruta (2013), the degree of technological diversification of partners presumes particular relevance, since it may influence the establishment and the productivity of the collaboration itself, due to the scope of the complementary relationship that is generated between partners.

The functionality of strategic alliance lies in the extent to which it guarantees efficiency and knowledge sharing among work groups between the allying partners. Moreover, strategic alliances are created with deliberate goals while to shape the operational resources of partners and provide needed capacity that strengthens the competitiveness of the firms (Mowla, 2012; Donnellan & Rutledge, 2019). Accordingly, due to accumulated learning, and experienced manpower the innovative firms enjoy higher efficiencies (Saranga & Phani, 2009). The survival and the growth of firms depend on the degree of operational efficiency that can achieve and driven by the level of technology innovation. Sarkis (2000), in his empirical study, focuses on 44 major US airports to evaluate their operational efficiencies. The results indicate that operations managers should evaluate andbenchmark their performances with airports having similar characteristics.

However, the previous literature studies strategic alliances without taking into consideration operational asset turnover, even though efficiency and innovation are necessary for the formation of a strategic system. At the same time, technological diversification and operationalefficiency are one of the biggest challenges that biopharmaceuticals face today.

All the above leads us to the following hypotheses:

Hypothesis 1: Technological diversification has a positive effect on a strategic alliance.

Hypothesis 2: Greater diversity of technology impacts strategic alliance positively.

Hypothesis 3: Level of operational efficiency is positively associated with strategic alliance.

3 | METHODOLOGY

3.1 Data and sample:

We conducted our study based on strategic partnerships data from 186 alliances formed by a limited sample of 72 firms, 48 U.S. companies (66,67%), and 24 European and Asian companies (33,33%). This covers the high-tech pharmaceuticals sector listed under the Standard Industrial Classification (SIC –code 283). Annual firm-level panel data was constructed from 2003 to 2013. While our sample size appears to be small in contrast to patternsizes among strategic alliances conducted at other sector settings, it is in line with bio- pharmaceutical industries data set used in preceding studies (Marhold & Kang, 2017).

To construct our datasets, we used various types of sources: Medtrack archive, Recap IQ databases as the main source of the strategic alliance's data, and Qpat-Orbit database for patent data. It was necessary to use one patent database rather than various patenting systems in orderto maintain a certain level of reliability, coherence, and comparability (Ahuja & Kalita, 2001). In addition, Orbis and Bloomberg's databases were used to provide firm-level data, such as financial data, firm size, age, region, and R&D expenditures for each company. Since the bio- pharmaceutical industry is composed of traditional pharmaceutical companies and dedicated biotechnology firms (Rothaermel, 2001), in the following step, we divided our sample depending on the firm sector's activity in two sub-sectors: Biotechnology and pharmaceuticals. We collected the required information regarding strategic alliances, technological diversification, and operating efficiency after an enormous effort of correction and revision. Afew companies had to be eliminated from our data because we did not have sufficientinformation on some of the variables required for analysis such as total assets or sales, or whenthe available alliance data were not adequate for the level of this study (Van de Vrande, 2013).

3.2 | Variables:

3.2.1 Dependent variable

The number of alliances is used as a dependent variable of this study, a count variable of the total agreements a bio-pharmaceutical firm has entered into with one or more partners. In total,we analyzed 186 strategic partnerings of firms in the observed years. This data is derived fromthe MedTrack and Recap IQ databases. MedTrack archive is the most comprehensive database of private and public biotech companies. The second database Recap IQ is a commercial database available from Thomson Reuters which can be used with private online access. This database provides the most important information about pharmaceutical industry alliances, including the functional activities performed by the alliance, partners, agreement date, descriptive information about the targeted technology, and the use of equity arrangements. These databases have been used in recent studies (Zidorn & Wagner, 2012; Liu et al., 2015). Itwas necessary to access more than one source in order to obtain complete data within the specified period of study.

3.2.2 Independent variables

Technological diversification: was computed using patent data drawn from the Qpat-Orbit database, classified according to the International Patent Classification (IPC classes). All patents contain one or more technology field IPC codes representing the yearly number of all patents accumulated by a firm. Analyzing the sample of 72 companies we observe that the firms had patents in at least 3 different fields, and the maximum value is 65 technology classes. In order to measure technological diversification (DivTech), and consistent with several previousstudies (Garcia-Vega, 2006; Leten et al., 2007; Chen et al., 2010; Corradini et al., 2016;

Natalicchio et al., 2017; Yun et al., 2019), we used Herfindahl-Hirschman Index (HHI).

The HHI based on their 3-digit main patent classes is constructed as follows:

$$DivTech_{it} = 1 - \sum_{j=1}^{K} (\frac{N_{ijt}}{N_{it}})^2$$

Let N_{ijt} denote the total number of patents held by the ith company in category j at time t, while j represents the IPC category where the company patented and K is the number of technological classes where the company was active.

Operational efficiency: there are several ways to measure operating efficiency through similar turnover ratios including fixed asset turnover (FAT) ratio, working capital ratio, and total assetsturnover (TAT) ratio. In our study, we choose using TAT for which we have available data. Moreover, it is often used as a financial ratio that measures the company's ability to use its assets in generating sales income to the company. We argue with previous literature that a firm'sprofitability is seen by looking at the recent past (Huang, Wang, and Lee, 2015). Thus, a one- year time lag was used to calculate the efficiency of the company's assets. Our primary source of past TAT was the Orbis database. Further, we controlled and augmented these data with Bloomberg's database and annual reports of firms.

Diversity increase: is an alternative variable of technological diversification, measured by a dummy variable in order to control for similar factors changing over time. It takes (1) when the inverse HHI has increased in the earlier year, (0) otherwise.

3.2.2 Control variables

In this study, we included control variables accounting for the age of the firm (**Firm Age**) measured as years since incorporation date and for the size of the firm (**Size**) defined as the total number of employees. Further, we controlled for the status of the firms (**ownership**) usinga dummy variable 1 if the firm is public, 0 otherwise (Messeni Petruzzelly et al, 2015). (**R&D expenditures)** research and development expense measured annually for each firm. All this data is gathered from the Orbis database provided by (BvD) Bureau Van Dijk, and through Bloomberg's as an additional database.

3.3 Estimation model:

Among the 72 firms that have been involved in 186 strategic alliances during the period studied, we have a total number of 792 firm-year observations, with an average of more than 11 observations per firm, in strongly balanced data.

The approach this study follows is to estimate the panel data model as follows:

$$Y_{i,t} = \alpha + \beta_1 X_{1i,t} + \beta_2 X_{2i,t} + \dots + \beta_n X_{ni,t} + \varepsilon_{i,t} \quad (1)$$

Where $Y_{i,t}$ is the dependent variable for a firm i at the time t, α is a constant coefficient and β_n represents the regression coefficient for the regressor X_n and $\varepsilon_{i,t}$ is an error term which captures all others omitted factors with $E[\varepsilon_{i,t} \mid X_{i,t}] = 0$ for all i and t.

Hence, our final regression model by selecting the control and independent variable will be asfollows:

$$SA_{i,t} = \alpha + \beta_1 DivTech_{i,t} + \beta_2 TAT_{i,t-1} + \beta_3 DI_{i,t} + \beta_4 FA_{i,t} + \beta_5 SIZE_{i,t} + \beta_6 ownership_{i,t} + \beta_7 Region_{i,t} + \beta_8 R\&D_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where

$SA_{i,t}$ is a total number of strategic alliance for the firm i at the time t, α is a constant coefficient, $DivTech_{i,t}$ is a technological diversification of firm i at the time t, $TAT_{i,t}$ is total asset turnover of the firm i at the time $t-1$, $DI_{i,t}$ is the diversity increase of firm i at the time t, $FA_{i,t}$ is firm age of firm i at the time t, $SIZE_{i,t}$ is the number of employees of firm i at thetime t, $ownership_{i,t}$ is Dummy variable of ownership of firm i at the time t, $Region_{i,t}$ is Dummy variable of the region of the firm i at the time t, $R\&D_{i,t}$ is research and development expenses firm i at time t, $\varepsilon_{i,t}$ is an error term which captures all others omitted factors with

$E[\varepsilon_{i,t} \mid X_{i,t}] = 0$ for all i and t.

3.4 Estimation Technique:

Among the 72 firms that have been involved in 186 strategic alliances during the period studied, we have a total number of 792 firm-year observations, with an average of more than 11 observations per firm in strongly balanced data.

4 | RESULTS

Table 1 presents a summary of the descriptive statistics including correlations among the variables used in this study. The correlation matrix shows a high level of correlation between the variables used in our model. To check for the possible presence of any multicollinearity issues, we analyzed the variance inflation factors (VIF) for all variables in the models. The results of this test are shown in **Table 2,** that the variables range from 1.02 to 5.62 and are belowthe cut-off point of 10 (Kleinbaum et al, 1998). This indicates no multicollinearity issues in ourdata.

Table 1: Descriptive statistics and Correlation matrix.

	Variables	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9
1	SA	0.23	0.47	1.0000								
2	DivTech	0.67	1.35	-0.3069	1.0000							
3	DI	0.56	0.50	0.0339	0.0594	1.0000						
4	TAT_{t-1}	0.40	0.39	0.1351	-0.1672	0.0227	1.0000					
5	SIZE	13650.85	29501.69	0.3282	-0.4081	0.0816	0.2234	1.0000				
6	FA	36.81	38.81	0.12	-0.0659	0.0512	0.2505	0.4730	1.0000			
7	Ownership(public=1)	0.79	0.41	-0.0555	0.0517	-0.0145	-0.055	0.076	0.1165	1.0000		
8	REGION (US=1)	0.67	0.47	-0.1235	0.2502	-0.0766	-0.237	-0.3343	-0.2019	0	1.0000	
9	R&D	661190.20	1439135.00	0.3107	-0.4188	0.072	0.1918	0.8973	0.4322	0.1009	-0.2819	1.0000

Table 2: VIF Test results.

Variable	VIF
SIZE	5.62
R&D	5.29
FA	1.39
DivTech	1.32
REGION	1.19
TAT	1.13
Ownership	1.04
DDI	1.02
Average VIF	2.25

Table 3: Regression Results.

Dependent Variable	Model 1		Model 2		Model 3		Model 4		Model 5	
Strategic alliances	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
DivTech			-0.079***	(0.013)					-0.073***	(0.015)
DDI					-0.007	(0.032)			0.022	(0.034)
L.TAT							0.082*	(0.045)	0.046	(0.046)
Number of employees	0.000***	(0.000)	0.000***	(0.000)	0.000***	(0.000)	0.000***	(0.000)	0.000***	(0.000)
AGE	-0.001	(0.000)	-0.000	(0.000)	-0.001	(0.000)	-0.001	(0.001)	-0.000	(0.001)

OwnershipPr	-0.083**	(0.039)	-0.064*	(0.039)	-0.084**	(0.039)	-0.088**	(0.042)	-0.079*	(0.042)
REGION_US	-0.007	(0.036)	0.026	(0.035)	-0.008	(0.036)	-0.006	(0.038)	0.019	(0.039)
RDExp	0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
_cons	0.244***	(0.045)	0.264***	(0.044)	0.248***		0.228***	(0.052)	0.261***	(0.056)
Adjusted R2	0.123		0.160		0.121		0.114		0.141	

t-statistics are in parentheses: - *** $p< 0.01$; - ** $p< 0.05$. - * $p< 0.1$

Table 3 presents the results of our regression analysis using the ordinary least squared (OLS) regression model. Model 1, is a baseline, it incorporates only the control variables used in our study. All the models "SIZE" show a positive and statistically significance. It indicates that thelargest firms in the biopharmaceutical industry tend to engage and/or influence the strategic alliance.

The other control variable "Ownership" shows a negative and statistically significant coefficient in all the models. Ownership is a dummy variable with 1 if it is a public company and 0 if it is owned privately. Hence, the result indicates publicly owned companies do not tend to engage in strategic alliances as opposed to privately owned companies. However, none of the other set of control variables, in all the models, appear to demonstrate statistically significant results. Model 2 tests hypothesis 1, which posits that internal technological diversification hasa positive influence on a strategic alliance. As can be seen in the model the coefficient for Technological diversification (*DivTech*) is negative and strongly significant (β = - 0.079, $p<$ 0.01) at 1% significance level also in the full model 5. Hence, this result does not support our hypothesis. Model 3 tests hypothesis 2, which predicts the increase of diversity has a positive impact on a strategic alliance. The coefficient for the increase of diversification (DDI) has a negative insignificant influence on strategic alliance (β = - 0.007, $p>$ 0.1) in that model and fullmodel 5. Hence, hypothesis 2 is not supported. Model 4 tests our hypothesis 3, which proposed that past operational efficiency, is positively associated with strategic alliance. As depicted in Table 3, the coefficient for last operational efficiency (used past TAT_{t-1} as a proxy) is positive and significant (β = 0.082, $p<$ 0.1) at a 10% significance level. In contrast, in the full model 5 the coefficient of this variable is positive and insignificant. Therefore, our hypothesis 3 is supported when model 3 is used but does not get support when the model is changed.

5 | DISCUSSION AND CONCLUSION

Despite the growing attention devoted to the impact of strategic alliances on innovation and financial performance, the study of the inverse effects is still in its beginning. The main aim ofthis study is to investigate the influence of technological diversification and operational efficiency for the previous year of firms with strategic alliances. Our empirical study focused on the biopharmaceutical industry in the high-tech sector, where the number of strategic alliances is higher than other areas within the same sector. Our hypotheses were tested on a sample of 72 biopharmaceutical companies engaging in over 186 strategic alliances within the period of 2003-2013. Our empirical results indicated a negative correlation between technological diversification on the number of strategic alliances. More broadly, companies that have less diversity in technological domains are more likely to engage in strategic partnershipswith other parties. This result contradicts the finding of previous authors in the strategic literature, which finds that the diversity of technology platforms encourages the use of alliances as a preferred mechanism for exploration or exploitation alliances (Gottinger & Umali, 2008; Hoang & Rothaermel, 2010; Yamakawa et al., 2011). While this result is in line with Kang & Marhold (2017), their study finds that increasing internal technological diversity of the technological resources in a firm has a negative effect on the diversity of its portfolio. This is consistent with Sampson, (2007) who suggests that when firms are entering alliances for the sake of new technological development, they should search for partners with non-similar technological capabilities.

Moreover, we also hypothesized that the operational efficiency of firms is positively associatedwith its number of strategic alliances. The result showed that a company with higher efficiency,measured by its last total asset turnover, gives investors an idea that the company is using its assets more efficiently and most likely will have good management and will use its assets to increase production.

REFERENCES

1. Ahuja, G. & Katila, R. (2001), 'Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study', Strategic management journal 22(3), 197--220.
2. Ahuja, G. (2000), 'Collaboration networks, structural holes, and innovation: A longitudinal study', Administrative science quarterly 45(3), 425--455.
3. Arora, A.; Fosfuri, A. & Gambardella, A. (2001), 'Markets for technology and their implications for corporate strategy', Industrial and corporate change 10(2), 419-451.
4. Belderbos, R.; Cassiman, B.; Faems, D.; Leten, B. & Van Looy, B. (2014), 'Co-ownership of intellectual property: Exploring the value-appropriation and value-creation implications of co- patenting with different partners', Research policy 43(5), 841--852.
5. Belussi, F. & Orsi, L. (2015), Innovation, Alliances, and Networks in High-tech Environments, Vol. 66, Routledge.
6. Bolli, T. & Woerter, M. (2013), 'Technological diversification and innovation performance',. Bolli, T.; Seliger, F. & Woerter, M. (2019), 'Technological diversity, uncertainty and innovation performance', Applied Economics, 1--14.
7. Breschi, S.; Lissoni, F. & Malerba, F. (2003), 'Knowledge-relatedness in firm technological diversification', Research policy 32(1), 69--87.
8. Cantwell, J. & Fai, F. (1999), 'Firms as the source of innovation and growth: the evolution of technological competence', Journal of Evolutionary Economics 9(3), 331--366.
9. Cassiman, B. & Veugelers, R. (2006), 'In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition', Management science 52(1), 68--82.
10. Ceipek, R., Hautz, J., Mayer, M. C., & Matzler, K. (2019). Technological diversification: A systematic review of antecedents, outcomes and moderating effects. International Journal of Management Reviews, 21(4), 466-497.
11. Chang, M.-H.; Liou, J. J. & Lo, H.-W. (2019), 'A Hybrid MCDM Model for Evaluating Strategic Alliance Partners in the Green Biopharmaceutical Industry', Sustainability 11(15), 4065.
12. Chen, J. H.; Jang, S.-L. & Wen, S. H. (2010), 'Measuring technological diversification: identifying the effects of patent scale and patent scope', Scientometrics 84(1), 265--275. Corradini, C.; Demirel, P. & Battisti, G. (2016), 'Technological diversification within UK's small serial innovators', Small Business Economics 47(1), 163--177.
13. Comai, A. (2019). A new approach for detecting open innovation in patents: the designation of inventor. The Journal of Technology Transfer, 1-26.
14. Dahlander, L. & Gann, D. M. (2010), 'How open is innovation?', Research policy 39(6), 699-- 709.
15. Dan, S. M., & Zondag, M. M. (2016). Drivers of alliance terminations: An empirical examination of the bio-pharmaceutical industry. Industrial Marketing Management, 54, 107- 115.
16. Donnellan, J., & Rutledge, W. L. (2019). A case for resource-based view and competitive advantage in banking. Managerial and Decision Economics, 40(6), 728-737.
17. Doz, Y. L. & Hamel, G. (1998), Alliance advantage: The art of creating value through partnering, Harvard Business Press.
18. Dyer, J. H.; Kale, P. & Singh, H. (2001), 'How to make strategic alliances work', MIT Sloan management review 42(4), 37.
19. Elmuti, D. & Kathawala, Y. (2001), 'An overview of strategic alliances', Management decision 39(3), 205--218.
20. Foroohar, R. (2018). Corporate elites are overlooking deglobalisation. Financial Times, 14.
21. Franco, M. & Haase, H. (2015), 'Interfirm alliances: a taxonomy for SMEs', Long Range Planning 48(3), 168--181.
22. Galunic, D. C., & Rodan, S. (1998). Resource recombinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. Strategic management journal, 19(12), 1193-1201.
23. Gambardella, A. & Torrisi, S. (1998), 'Does technological convergence imply convergence in markets? Evidence from the electronics industry', Research policy 27(5), 445--463.
24. Garcia-Canal, E.; Duarte, C. L.; Criado, J. R.; Llaneza, A. V. & others (2002), 'Accelerating international expansion through global alliances: a typology of cooperative strategies', Journal of World Business 37(2), 91--107.
25. Garcia-Vega, M. (2006), 'Does technological diversification promote innovation?: An empirical analysis for European firms', Research policy 35(2), 230--246.
26. Giuri, P.; Hagedoorn, J. & Mariani, M. (2004), 'Technological diversification and strategic alliances', The economics and management of technological diversification. Routledge, London and New York, 116--151.
27. Gottinger, H.-W. & Umali, C. L. (2008), 'Strategic alliances in global biotech pharma industries', The Open Business Journal 1(1), 10--24.
28. Granstrand, O. (2000), 'Corporate Innovation Systems: A Comparative Study of Multi- Technology Corporations in Japan, Sweden and the USA', Chalmers University, Gothenburg. Granstrand, O. (2003), Innovations and Intellectual Property Studies' Economics, law and intellectual property', Springer, , pp. 9--40.

29. Granstrand, O.; Patel, P. & Pavitt, K. (1997), 'Multi-technology corporations: why they have “distributed” rather than “distinctive core” competencies', California management review 39(4), 8--25.
30. Gulati, R. (1998), 'Alliances and networks', Strategic management journal 19(4), 293--317. Haeussler, C.; Patzelt, H. & Zahra, S. A. (2012), 'Strategic alliances and product development in high technology new firms: The moderating effect of technological capabilities', Journal of business venturing 27(2), 217--233.
31. Hagedoorn, J. (1993), 'Understanding the rationale of strategic technology partnering: Nterorganizational modes of cooperation and sectoral differences', Strategic management journal 14(5), 371--385.
32. He, Q., Meadows, M., Angwin, D., Gomes, E., & Child, J. (2020). Strategic alliance research in the era of digital transformation: Perspectives on future research. British Journal of Management, 31(3), 589-617.
33. Hoang, H. & Rothaermel, F. T. (2010), 'Leveraging internal and external experience: exploration, exploitation, and R&D project performance', Strategic Management Journal 31(7), 734--758.
34. Hohberger, J.; Almeida, P. & Parada, P. (2015), 'The direction of firm innovation: The contrasting roles of strategic alliances and individual scientific collaborations', Research policy 44(8), 1473--1487.
35. Huang, S.-M.; Xu, S.-Y.; Belopolski, I.; Lee, C.-C.; Chang, G.; Wang, B.; Alidoust, N.; Bian, G.; Neupane, M.; Zhang, C. & others (2015), 'A Weyl Fermion semimetal with surface Fermiarcs in the transition metal monopnictide TaAs class', Nature communications 6, 7373. Huang, Y.-F. & Chen, C.-J. (2010), 'The impact of technological diversity and organizational slack on innovation', Technovation 30(7), 420--428.
36. Ireland, R. D.; Hitt, M. A. & Vaidyanath, D. (2002), 'Alliance management as a source of competitive advantage', Journal of management 28(3), 413--446.
37. Jee, S. J., & Sohn, S. Y. (2020). Patent-based framework for assisting entrepreneurial firms’ R&D partner selection: Leveraging their limited resources and managing the tension between learning and protection. Journal of Engineering and Technology Management, 57, 101575.
38. Kale, P.; Singh, H. & Perlmutter, H. (2000), 'Learning and protection of proprietary assets in strategic alliances: Building relational capital', Strategic management journal, 217--237.
39. Kao, C.-L.; Chen, L.-K.; Chang, Y.-L.; Yung, M.-C.; Hsu, C.-C.; Chen, Y.-C.; Lo, W.-L.; Chen,
40. Kauser, S. & Shaw, V. (2004), 'International Strategic Alliances: objectives, motives and success', Journal of Global Marketing 17(2-3), 7--43.
41. Kim, H.; Lim, H. & Park, Y. (2009), 'How should firms carry out technological diversification to improve their performance? An analysis of patenting of Korean firms', Economics of Innovation and New Technology 18(8), 757--770.
42. Kim, J.; Lee, C.-Y. & Cho, Y. (2016), 'Technological diversification, core-technology competence, and firm growth', Research Policy 45(1), 113--124.
43. Kleinbaum, D.; Kupper, L.; Muller, K. & Nizam, A. (1998), 'Regression diagnostics', Applied regression analysis and other multivariable methods 2.
44. Koka, B. R. & Prescott, J. E. (2008), 'Designing alliance networks: the influence of network position, environmental change, and strategy on firm performance', Strategic Management Journal 29(6), 639--661.
45. Kook, S. H.; Kim, K. H. & Lee, C. (2017), 'Dynamic Technological Diversification and Its Impact on Firms’ Performance: An Empirical Analysis of Korean IT Firms', Sustainability 9(7), 1239.
46. Koren, M. & Tenreyro, S. (2013), 'Technological diversification', The American Economic Review 103(1), 378--414.
47. Krammer, S. M. (2016), 'The role of diversification profiles and dyadic characteristics in the formation of technological alliances: Differences between exploitation and exploration in a low-tech industry', Research Policy 45(2), 517--532.
48. Lalor, F.; Fitzpatrick, J.; Sage, C. & Byrne, E. (2019), 'Sustainability in the biopharmaceutical industry: Seeking a holistic perspective', Biotechnology advances.
49. Lavie, D., & Miller, S. R. (2008). Alliance portfolio internationalization and firm performance. Organization science, 19(4), 623-646.
50. Lee, C.-Y.; Wang, M.-C. & Huang, Y.-C. (2015), 'The double-edged sword of technological diversity in R&D alliances: Network position and learning speed as moderators', European Management Journal 33(6), 450--461.
51. Leten, B.; Belderbos, R. & Van Looy, B. (2007), 'Technological diversification, coherence, and performance of firms', Journal of Product Innovation Management 24(6), 567--579.
52. Li, K., Qiu, J., & Wang, J. (2019). Technology conglomeration, strategic alliances, and corporate innovation. Management Science, 65(11), 5065-5090.
53. Lichtenthaler, U. & Ernst, H. (2007), 'External technology commercialization in large firms: results of a quantitative benchmarking study', r&d Management 37(5), 383--397.
54. Liu, D.; Pu, X. & Schramm, M. E. (2016), 'Stock Market Response to Strategic Technical Alliances between Drug and Biotechnology Firms', Journal of Product Innovation Management 33(5), 549--569.
55. Lo, F.-Y.; Stepicheva, A. & Peng, T.-J. A. (2016), 'Relational capital, strategic alliances and learning: In-depth analysis of Chinese-Russian cases in Taiwan', Chinese Management Studies 10(1), 155--183.
56. Marhold, K. & Kang, J. (2017), 'The effects of internal technological diversity and external uncertainty on technological alliance portfolio diversity', Industry and Innovation 24(2), 122-- 142.
57. Messeni Petruzzelli, A.; Natalicchio, A. & Garavelli, A. C. (2015), 'Investigating the determinants of patent acquisition in biotechnology: an empirical analysis',

Technology Analysis & Strategic Management 27(7), 840--858.
58. Mindruta, D. (2013), 'Value creation in university-firm research collaborations: A matching approach', Strategic Management Journal 34(6), 644--665.
59. Mohr, J. & Spekman, R. (1994), 'Characteristics of partnership success: partnership attributes, communication behavior, and conflict resolution techniques', Strategic management journal 15(2), 135--152.
60. Natalicchio, A.; Petruzzelli, A. M. & Garavelli, A. C. (2017), 'The impact of partners' technological diversification in joint patenting', Management Decision.
61. Ohba, M., & Figueiredo, P. N. (2007). Innovative capabilities and strategic alliances: Who is gaining what in the pharmaceutical industry?. Journal of commercial biotechnology, 13(4), 273-282.
62. Oxley, J. E., & Sampson, R. C. (2004). The scope and governance of international R&D alliances. Strategic Management Journal, 25(8-9), 723-749.
63. Park, S. H.; Chen, R. R. & Gallagher, S. (2002), 'Firm resources as moderators of the relationship between market growth and strategic alliances in semiconductor start-ups', Academy of management Journal 45(3), 527--545.
64. Patel, P. & Pavitt, K. (1997), 'The technological competencies of the world's largest firms: complex and path-dependent, but not much variety', Research policy 26(2), 141--156.
65. Pavitt, K. (1998), 'Technologies, products and organization in the innovating firm: what Adam Smith tells us and Joseph Schumpeter doesn't, Industrial and Corporate change 7(3), 433--452. Perry, M. L.; Sengupta, S. & Krapfel, R. (2004), 'Effectiveness of horizontal strategic alliances in technologically uncertain environments: are trust and commitment enough?', Journal of Business Research 57(9), 951--956.
66. Quintana-Garcia, C. & Benavides-Velasco, C. A. (2008), 'Innovative competence, exploration and exploitation: The influence of technological diversification', Research Policy 37(3), 492-- 507.
67. Ramasamy, S. V.; Titchener-Hooker, N. J. & Lettieri, P. (2015), 'Life cycle assessment as a tool to support decision making in the biopharmaceutical industry: Considerations and challenges', Food and Bioproducts Processing 94, 297--305.
68. Rosenberg, N. (1976), Perspectives on technology, CUP Archive.
69. Rothaermel, F. T. & Deeds, D. L. (2006), 'Alliance type, alliance experience and alliance management capability in high-technology ventures', Journal of business venturing 21(4), 429--460.
70. Rothaermel, F. T. (2001), 'Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry', Research policy 30(8), 1235--1251.
71. Rothaermel, F. T., & Boeker, W. (2008). Old technology meets new technology: Complementarities, similarities, and alliance formation. Strategic management journal, 29(1), 47-77.
72. Rybka, J., Roijakkers, N., Lundan, S., & Vanhaverbeke, W. (2015). Strategic alliances for the development of innovative SMEs in the biopharmaceutical industry. Strategic alliances for SME developement. Information Age Publishing, 245-260.
73. S.-J.; Ku, H.-H. & Hwang, S.-J. (2010), 'Resveratrol protects human endothelium from H2O2- induced oxidative stress and senescence via SirT1 activation', Journal of atherosclerosis and thrombosis 17(9), 970--979.
74. Sampson, R. C. (2007), 'R&D alliances and firm performance: The impact of technological diversity and alliance organization on innovation', Academy of management journal 50(2), 364--386.
75. Saranga, H., & Phani, B. V. (2009). Determinants of operational efficiencies in the Indian pharmaceutical industry. International transactions in operational research, 16(1), 109-130.
76. Sarkis, J. (2000). An analysis of the operational efficiency of major airports in the United States. Journal of Operations management, 18(3), 335-351.
77. Schildt, H. A.; Maula, M. V. & Keil, T. (2005), 'Explorative and exploitative learning from external corporate ventures', Entrepreneurship Theory and Practice 29(4), 493--515.
78. Schuhmacher, A.; Germann, P.-G.; Trill, H. & Gassmann, O. (2013), 'Models for open innovation in the pharmaceutical industry', Drug discovery today 18(23-24), 1133--1137.
79. Van de Vrande, V. (2013), 'Balancing your technology-sourcing portfolio: How sourcing mode diversity enhances innovative performance', Strategic Management Journal 34(5), 610--621.
80. Yamakawa, Y.; Yang, H. & Lin, Z. J. (2011), 'Exploration versus exploitation in alliance portfolio: Performance implications of organizational, strategic, and environmental fit', Research Policy 40(2), 287--296.
81. Yun, S.; Lee, J. & Lee, S. (2019), 'Technology development strategies and policy support for the solar energy industry under technological turbulence', Energy Policy 124, 206--214.
82. Zhang, G., & Tang, C. (2018). How R&D partner diversity influences innovation performance: an empirical study in the nano-biopharmaceutical field. Scientometrics, 116(3), 1487-1512.
83. Zidorn, W. & Wagner, M. (2012), 'The effect of alliances on innovation patterns: an analysis of the biotechnology industry', Industrial and corporate change 22(6), 1497—1524